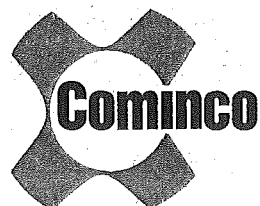


COMINCO LTD. TRAIL OPERATIONS

Environmental Performance Review
of the New KIVCET Lead Smelter
and Elimination of Slag Discharge:

Assessment of Columbia River
Receiving Waters, Summary



RESOURCEFUL-WORLDWIDE



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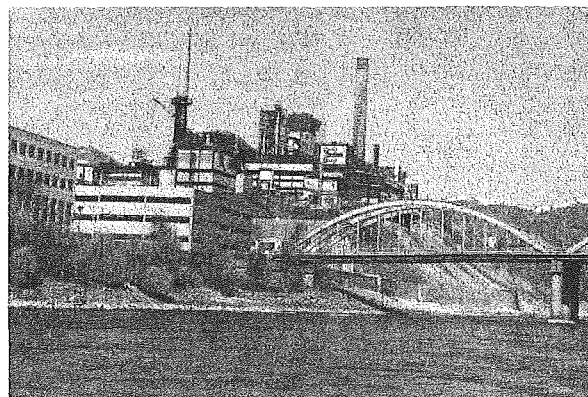
1.0 Introduction

Smelter operations have been underway in Trail, British Columbia, since 1896, with the Consolidated Mining and Smelting Company of Canada Ltd. (Cominco) formed in 1906. Cominco Trail Operations smelts zinc, lead, cadmium, silver, gold, copper and other products from ores mined in various regions of North and South America. The facilities have been modified and upgraded many times in the last century. Cominco has invested over one billion dollars in the last 25 years, modernizing production efficiency and improving environmental performance. Between 1980 and 1995, contaminants were removed from various effluent streams, effluent treatment was improved, and the phosphate fertilizer plant was closed. These upgrades resulted in substantial decreases in discharges of many compounds, particularly cadmium, mercury, lead, arsenic and phosphate. Recent upgrades (1995 to 1999) include the installation of a new lead smelter using KIVCET technology and the elimination of slag discharge to the Columbia River. Slag is a by-product of the smelting furnaces that contains glassy particulate matter and metals. These recent changes have led to sizable improvements in effluent and receiving water quality as well as significant improvement in air quality.

The Columbia River is one of the largest rivers in North America, draining a large part of eastern British Columbia and several northwest US states. It is highly complex and dynamic, with seasonal changes, daily fluctuations and a variety of habitat types along its length. Hugh Keenleyside, Brilliant and several other dams upstream of Cominco regulate river flows. Other human activities in the watershed are extensive: the Celgar Pulpmill upstream of Castlegar, the Cominco Smelter at Trail, urban runoff and municipal discharge from Trail, Castlegar and other communities, agriculture, mining, forestry, and other industries and businesses. In addition, numerous tributaries enter the Columbia, contributing unique combinations of metals and other compounds.

Designing an environmental study of this complex watershed, with its diverse human and natural influences, can be difficult. In the early 1990s, the Columbia River Integrated Environmental Monitoring Program

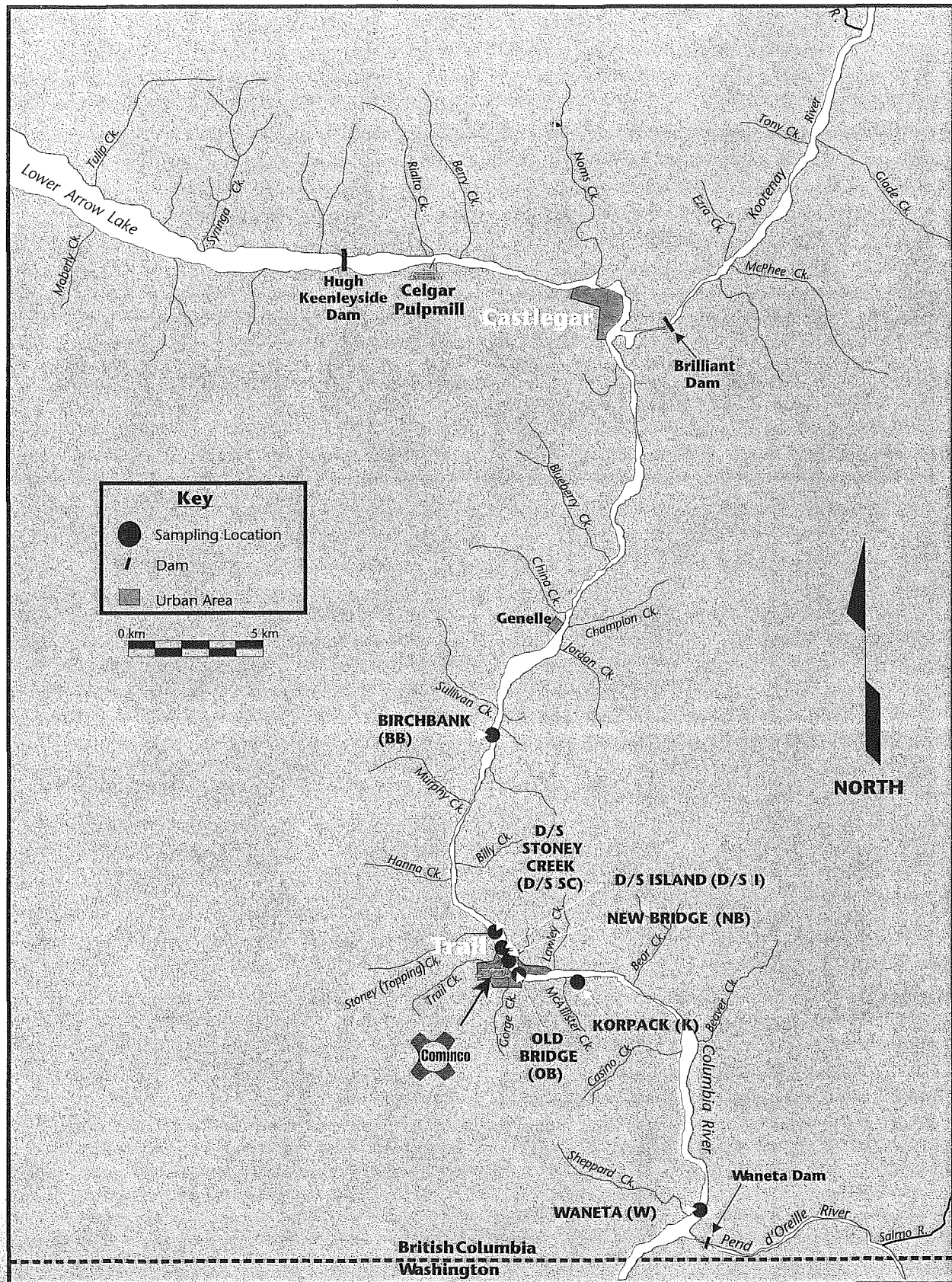
(CRIEMP) was established, bringing together representatives of industry, utilities, municipal governments, Ministry of Environment, Lands and Parks (MELP), Environment Canada (EC), and Fisheries and Oceans Canada (DFO) to study the Columbia River. The 1994 CRIEMP report recognized the difficulties in designing an environmental study, interpreting the results and attributing improvements or problems to specific sources. Several improvements in health of the Columbia River, as well as ongoing problems, were identified at that time.



Cominco Trail Operations as seen from the Columbia River.

Cominco implemented two major upgrades at the Trail facility following the CRIEMP study, the elimination of slag discharge and the construction of a new KIVCET lead smelter. The discharge of slag to the Columbia River was discontinued in mid-1995. Prior to this, up to 145,000 tonnes of slag had been discharged annually, which moved downstream to settle out in slower flowing, sandy areas. The environmental effects of slag discharge to the river included both chemical and physical components. Chemical effects included increased loads of heavy metals and potential bioaccumulation and toxicity problems in river organisms. Physical effects included scouring of plant and animal life from river substrates, damage to gills and soft tissues of aquatic insects and fish, and smothering of habitat and food sources. Since mid-1995, a slag product has been provided to the concrete industry as part of the reduction process. The KIVCET lead smelter was commissioned in 1997 and became fully operational in 1999, providing a new smelting furnace and improved air emission and effluent treatment controls. A substantial reduction in the release of particulate matter, metals and sulphur dioxide to air and water accompanied this upgrade.

Lower Columbia River Between Castlegar and the Canada – US Border, Showing Sampling Sites



2.0 Study Design

Cominco designed a study to examine the relationship of metal loads from the Trail facility to the health of plants and animals in the Columbia River before (spring 1995) and after (spring and fall 1999) the smelter upgrades and slag removal. Several test stations were established between Birchbank, 10.5 km upstream of the smelter, and Waneta, 16.5 km downstream (see map), including sites downstream of Cominco effluent discharges (D/S Stoney Creek, D/S Island, and New Bridge), as well as Old Bridge and Korpac. The results presented here summarize a large amount of information published in technical reports.

Effluents and receiving water are monitored routinely as part of Cominco's provincial discharge permit under the *BC Waste Management Act*. For the current study, metal concentrations in river water, bottom sediment and suspended sediment were measured over 30-day periods in spring 1995, spring 1999 and fall 1999. Artificial substrates were placed in the river to assess algae and aquatic insects during the same 30-day periods. Artificial substrates were used to address issues associated with fluctuating water flow in the highly regulated river and to enable sampling at specific locations of interest. Metal concentrations in the muscle tissue of mountain whitefish and rainbow trout caught near Trail were measured in both years. In addition, metal concentrations were measured in the water and sediment of numerous tributary creeks.

Table 1. Percent Reduction in Metals Discharged from Cominco, 1995 to 1999

	Total (air+slag+water)	Water
Zinc	92%	63%
Lead	77%	87%
Copper	99%	na
Arsenic	90%	85%
Cadmium	84%	81%
Mercury	95%	67%

na = total values not available for comparison

The design of the spring 1999 study was modified to account for a short-term maintenance shut-down of the KIVCET smelter. Biological sampling was not done at sites near the smelter (D/S Island, New Bridge, Old Bridge) at that time. However, other smelter processes and effluent treatment systems were in operation in spring 1999. The study was repeated in fall 1999 to further assess effects near Cominco.

3.0 Results

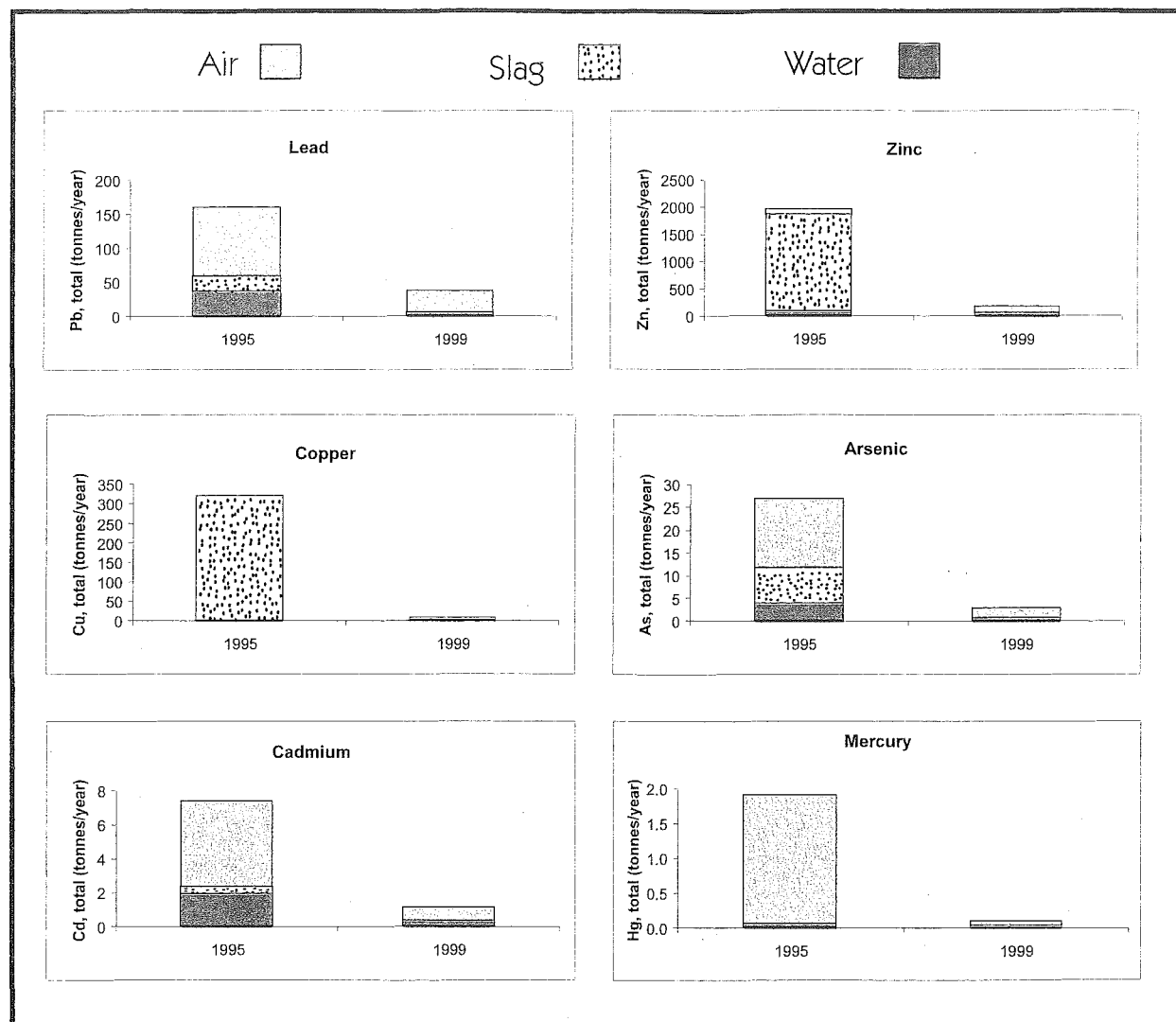
3.1 Effluent

Between 1995 and 1999, there were major reductions in lead, zinc, copper, arsenic, cadmium and mercury discharges from Cominco Trail Operations. These changes resulted from improvements in air emissions and liquid effluent, and the elimination of slag discharge to the Columbia River. Table 1 shows the percent reduction and Figure 1 shows the quantities for several key metals from all sources (air, slag, water) and from water alone, directly discharged to the Columbia River.

In 1995, the final year of release, 69,000 tonnes of slag were discharged to the Columbia River. Earlier in the 1990s, annual slag discharge ranged from 85,000 to 145,000 tonnes per year.

3.2 Water Quality

Metal concentrations in the Columbia River, downstream of smelter outfalls, decreased considerably between 1995 and 1999 (Figure 2) in response to decreased effluent loads. The improvements measured at New Bridge, downstream of all Cominco effluent discharge sources, were particularly apparent. In spring 1999, arsenic and mercury levels were reduced to below analytical detection limits at all sites (1 µg/L for arsenic, 0.05 µg/L for mercury). Zinc, lead, copper and cadmium concentrations were greatly reduced in spring and fall 1999, compared to spring 1995, but remained highest at New Bridge, downstream of all outfalls. The KIVCET smelter was operating during only part of the spring 1999 sampling period, which may have affected mean concentrations. However, similar reductions measured during the fall 1999 sampling period suggest a consistent trend.

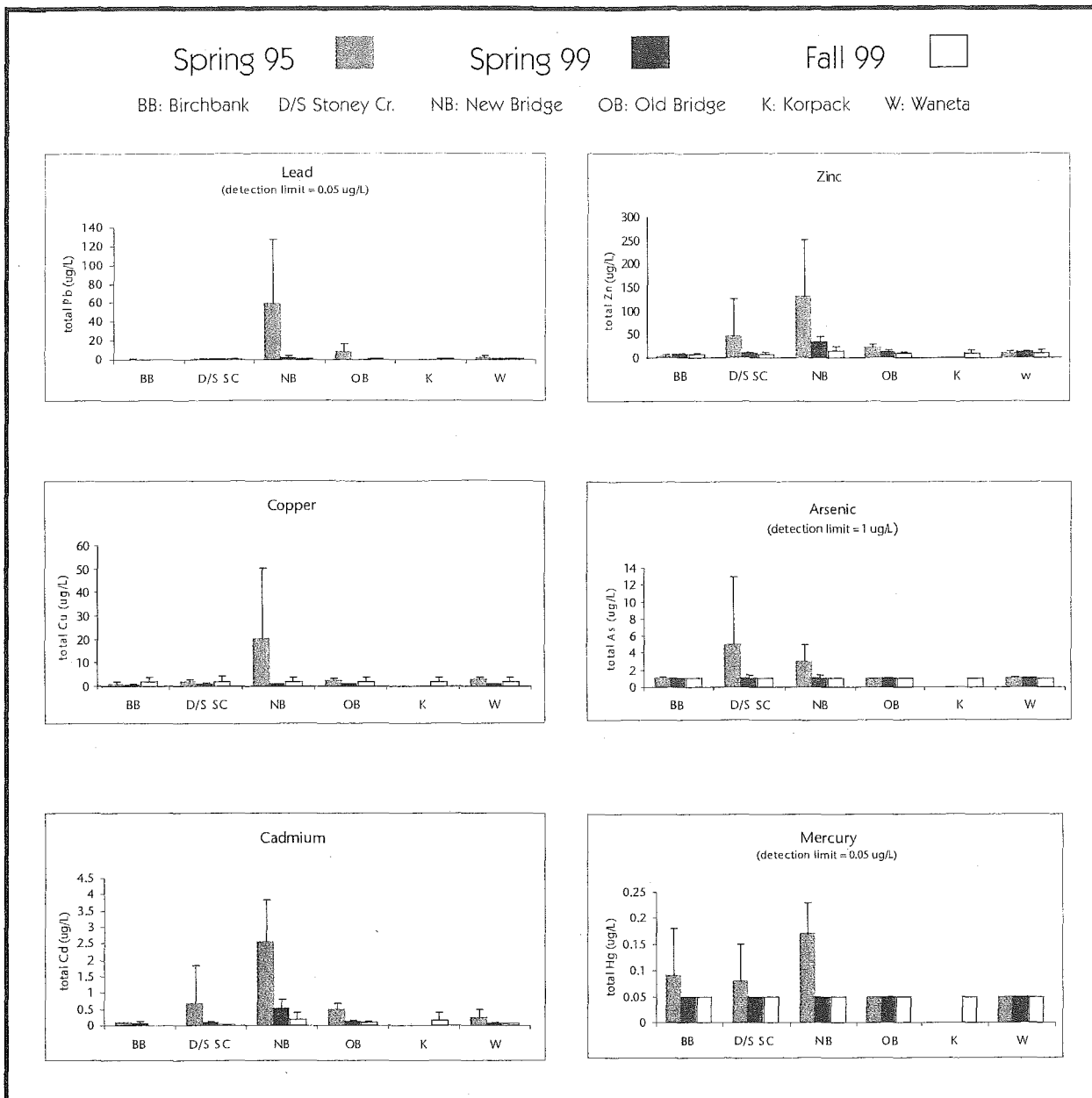
FIGURE 1 – Metal Discharges from Cominco, 1995 and 1999

The provincial *Ambient Water Quality Objectives for the Lower Columbia River* are designed to be met at sites outside the effluent mixing zone (i.e., not at D/S Island or New Bridge). The objectives were modified to become site-specific, rather than province-wide, between 1995 and 2000. In 1999, updated objectives for water were achieved for average concentrations of copper, lead and arsenic (well below the objectives). Mercury, for which there are no current water guidelines, was not detectable. Cadmium levels slightly exceeded the objectives at Old Bridge. Zinc concentrations, while substantially reduced from 1995, exceeded the revised objective at all sites downstream of the smelter. In spring 1999, zinc concentrations exceeded the objectives even at Birchbank, 10.5 km upstream of Trail, suggesting analytical problems measuring low levels of zinc. The results also

may indicate naturally high zinc levels in the watershed due to mineralization, or possible transport of air emissions from Cominco.

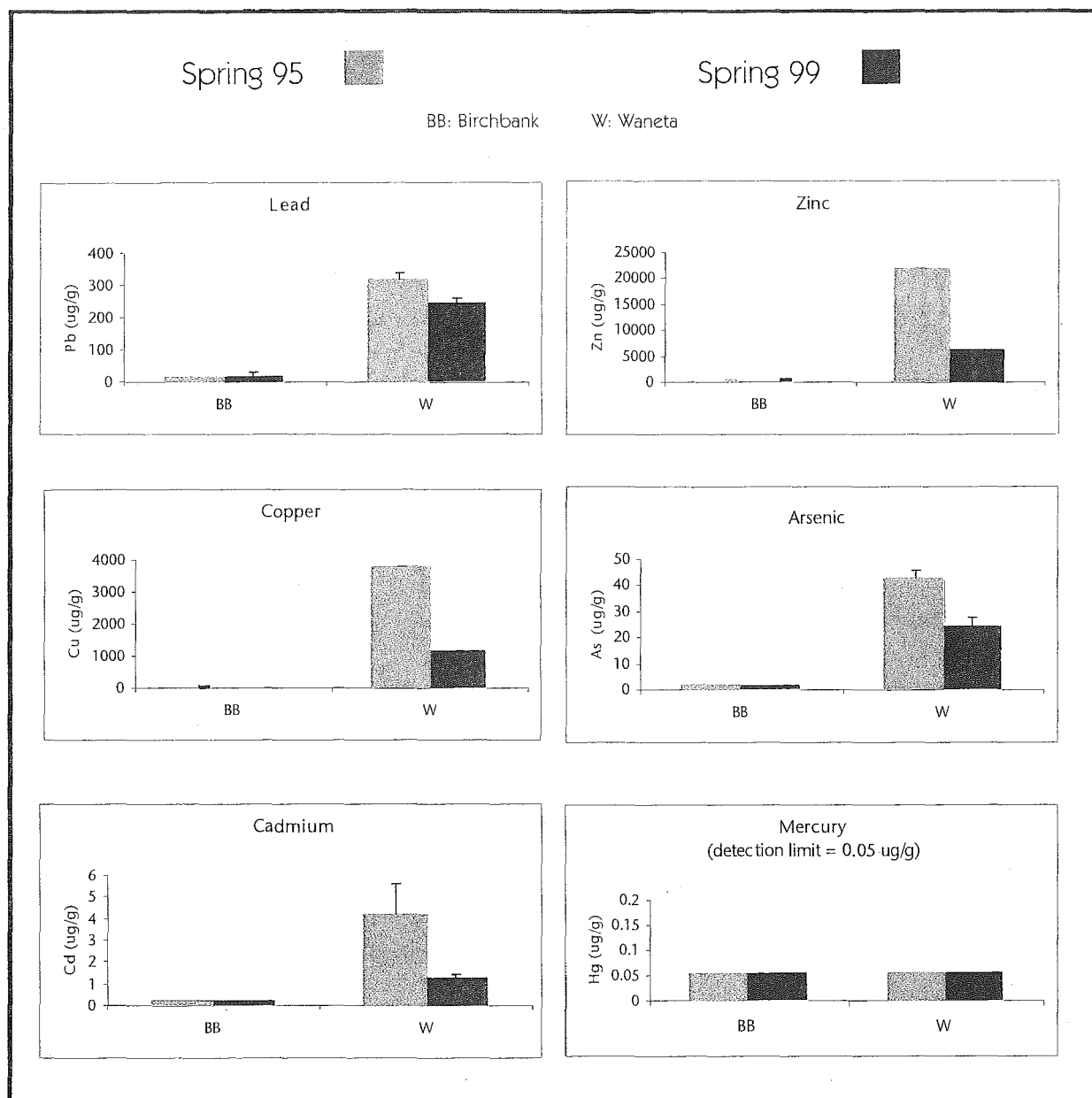
3.3 Sediment Quality

Bottom sediments were sampled in the Columbia River at Birchbank (10.5 km upstream of Trail), and Waneta (16.5 km downstream) in sandy depositional areas and in several tributaries. Metal concentrations were much higher at Waneta than at Birchbank in both years. However, levels at Waneta decreased considerably between 1995 and 1999, as shown in Figure 3. These represented reductions of 74% for zinc, 71% for copper and cadmium, 44% for arsenic, and 24% for lead. There was no change measured for mercury, as these levels were already below the detection limit (0.05 µg/g in 1995 and 0.02 µg/g in 1999).

FIGURE 2 – Metal Levels in Columbia River Water (mean \pm s.d., n=5)

Prior to publication of the *Ambient Water Quality Objectives for the Lower Columbia River* in 2000, there were no water quality objectives for sediment. Although substantial reductions were measured between 1995 and 1999, levels of zinc, lead, copper, arsenic and cadmium exceeded these recent objectives. The elimination of slag discharge from Cominco's Trail smelter in mid-1995 removed a major source of particulate metals to the river. Depositional bottom sediments at Waneta are good indicators of improvements related to Cominco because of their relative stability and should continue to show improvements.

Suspended sediment traps were used to examine trends in metal levels close to Cominco, since the Columbia was fast flowing in this region and there were no suitable natural sampling areas. Placing and maintaining equipment in this part of the river was difficult. The most obvious trend was the elimination of slag discharge. Traps at New Bridge, downstream of the discharge site, collected a large quantity of sediment containing slag and metals compared to other sites in 1995 but not in 1999 (Figure 4). Metal concentrations in suspended sediment, not shown in the figure, increased at sites immediately down-

FIGURE 3 – Metal Levels in Columbia River Sediment (mean \pm s.d., n=3)

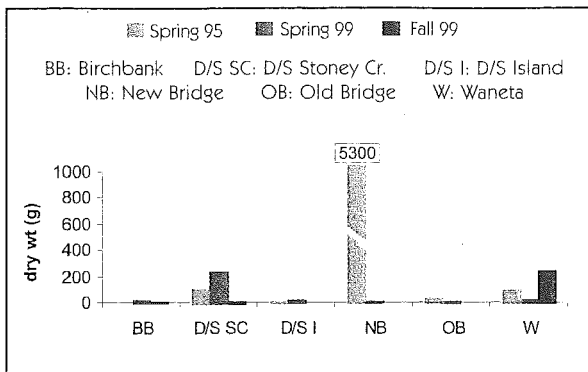
stream of Cominco outfalls, as well as further downstream (Old Bridge, Waneta) in both 1995 and 1999, but the actual quantities of metals were much smaller in 1999.

3.4 Tributaries

Elevated metal concentrations were measured in water and sieved fine sediment sampled from some creeks between Birchbank and Waneta, particularly Stoney Creek in Trail. Improvements were noted in some creeks between 1995 and 1999, which might be related to reduced air emissions from Cominco. High metal levels in

tributaries appeared to be related to historic or current mining activities, natural levels in the watersheds, influences of Cominco (fallout from air emissions, storm water runoff, historical practices) and urbanization in Trail. The tributary study suggested possible metal sources in addition to Cominco effluents and also relatively high background levels in some watersheds.

Concentrations of one or more metals exceeded the *Ambient Water Quality Objectives* for water or sediment in McNally Creek (3 km upstream of Cominco) and Stoney, Trail and Gorge creeks (near

FIGURE 4 – Suspended Sediment Dry Weight

Cominco). Tributaries downstream of Cominco with elevated metals included Bear Creek (5 km downstream), Beaver Creek (7 km downstream), and Sheppard Creek (downstream of Waneta). The Kootenay Regional District sewage treatment plant discharge (downstream of Bear Creek) was another significant source of metals. Metal levels in Stoney Creek improved greatly in spring 1999, after Cominco built a drainage collection system to collect and divert groundwater to an effluent treatment system before it enters the creek. The Stoney Creek watershed was used historically for storage of wastes and materials from Cominco's industrial processes.

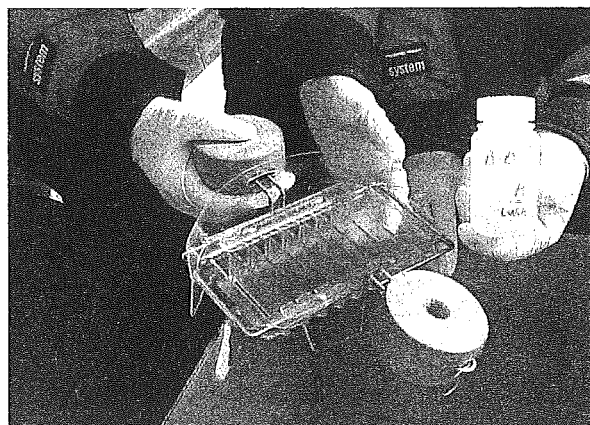
3.5 Bioassays

Laboratory bioassays were used to measure acute (immediate) and chronic (long term) toxicity of Cominco effluents, river water and sediment. Effluent from some of the smelter outfalls was acutely toxic to rainbow trout in 1995. Studies traced much of the toxicity to cadmium and zinc. Cominco subsequently developed a recovery process for these metals, substantially reducing their levels in effluent. By 1999, effluents were non-toxic to rainbow trout under normal operating conditions, although toxicity problems arose occasionally, related either to process upsets at the smelter or analytical problems at the bioassay laboratory. Bioassays of river water taken downstream of effluent discharges showed no acute or chronic toxicity in 1995 for bacteria, water fleas and rainbow trout tested. This finding indicated rapid dilution of effluents in the river. Sediment bioassays with midge larvae in 1995 showed toxicity associated with sediment at New Bridge (mostly slag collected in sediment traps), while not at Birchbank (10.5 km upstream) or Waneta (16.5 km downstream). Although survival rates were statistically similar at

Birchbank and Waneta, growth rates were lower at Waneta in both 1995 and 1999 (possibly related to physical effects of slag deposited over time at Waneta).

3.6 Algae

Periphyton consist of algae, simple plants that grow on rocks, wood, sand and larger plants. They are an important component of the food web and are food for many stream organisms. Much is known about the sensitivity of algae to metals, making them particularly useful to study in relation to smelter effluent discharges. Their growth is affected by many other environmental factors, including substrate, water velocity over the substrates, floods, nutrients, turbidity and seasonal light levels. In an attempt to reduce the number of variables affecting growth, artificial



Periphyton samplers used in the study.

substrate samplers were used to assess growth over a one-month period. However, there were some difficulties maintaining consistent locations under fluctuating river conditions and sometimes samplers were lost or moved into slower flowing areas. Some trends were apparent from the considerable amount of information collected about quantities and species of algae.

In spring 1995, the effects of slag and effluent were obvious downstream of smelter outfalls. Species composition changed between Birchbank (the upstream reference site) and D/S Stoney Creek. Abundance decreased substantially, and species composition shifted even more markedly at D/S Island and Old Bridge. Algal growth and species composition had recovered at Waneta and was somewhat similar to Birchbank.

In spring 1999, there was a moderate increase in accumulation at D/S Stoney Creek and a large increase at Waneta compared to both 1995 and Birchbank. Despite differences in accumulation, species composition was more similar at the three sites than it had been in 1995. These changes may have been related to improvements at Cominco's Trail operations, as well as other differences in growing conditions between the two years. Differences among sites in factors such as nutrient levels may have become important determinants of periphyton growth once the metal loads were reduced. Periphyton growth was not assessed downstream of smelter outfalls as the KIVCET smelter was shut down for part of this period.

In fall 1999, periphyton accumulation continued to be low downstream of Cominco outfalls (New Bridge), but growth and species composition had recovered at Old Bridge and Waneta and was similar to Birchbank. This result may indicate a smaller zone of influence of smelter effluents than in 1995, as well as the effects of other environmental factors, such as reduced light levels and higher river flows in the fall.

3.7 Aquatic Insects

Aquatic insects and other macroinvertebrates (bugs) typically grow in bottom substrates (boulders, cobbles, sand) and drift downstream in the current. These insects are food for many types of fish. They have been well studied in relation to pollution sources and water quality, so are considered good indicators of river health. Because of difficulties finding consistent, accessible sampling areas, samples were collected using artificial substrates suspended in the Columbia River for one month in spring 1995, spring 1999 and fall 1999. These samplers are not intended to imitate natural bottom substrates, but rather provide information about survival of organisms drifting downstream and, hence, about relative river health.

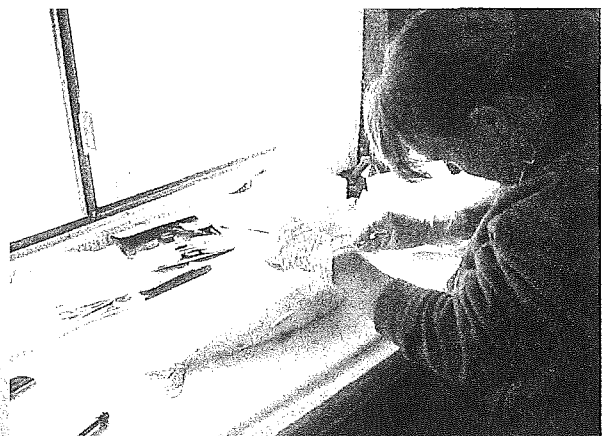
In general, results showed an effect downstream from smelter outfalls and recovery further downstream. Abundance (number of organisms) was highest at Birchbank and D/S Stoney Creek, and decreased at D/S Island and New Bridge. Abundance increased again farther downstream (Old Bridge in spring 1995, Korpak in fall 1999), then decreased at Waneta. The lower abundance

at Waneta than Birchbank may have been due, in part, to causes unrelated to smelter operations, given the 27 km distance between sampling sites. There was an assortment of pollution-tolerant species (midges, blackflies) and pollution-intolerant species (mayflies, caddisflies) at each site, including sites in Trail, with a drop in number of species immediately downstream of outfalls.

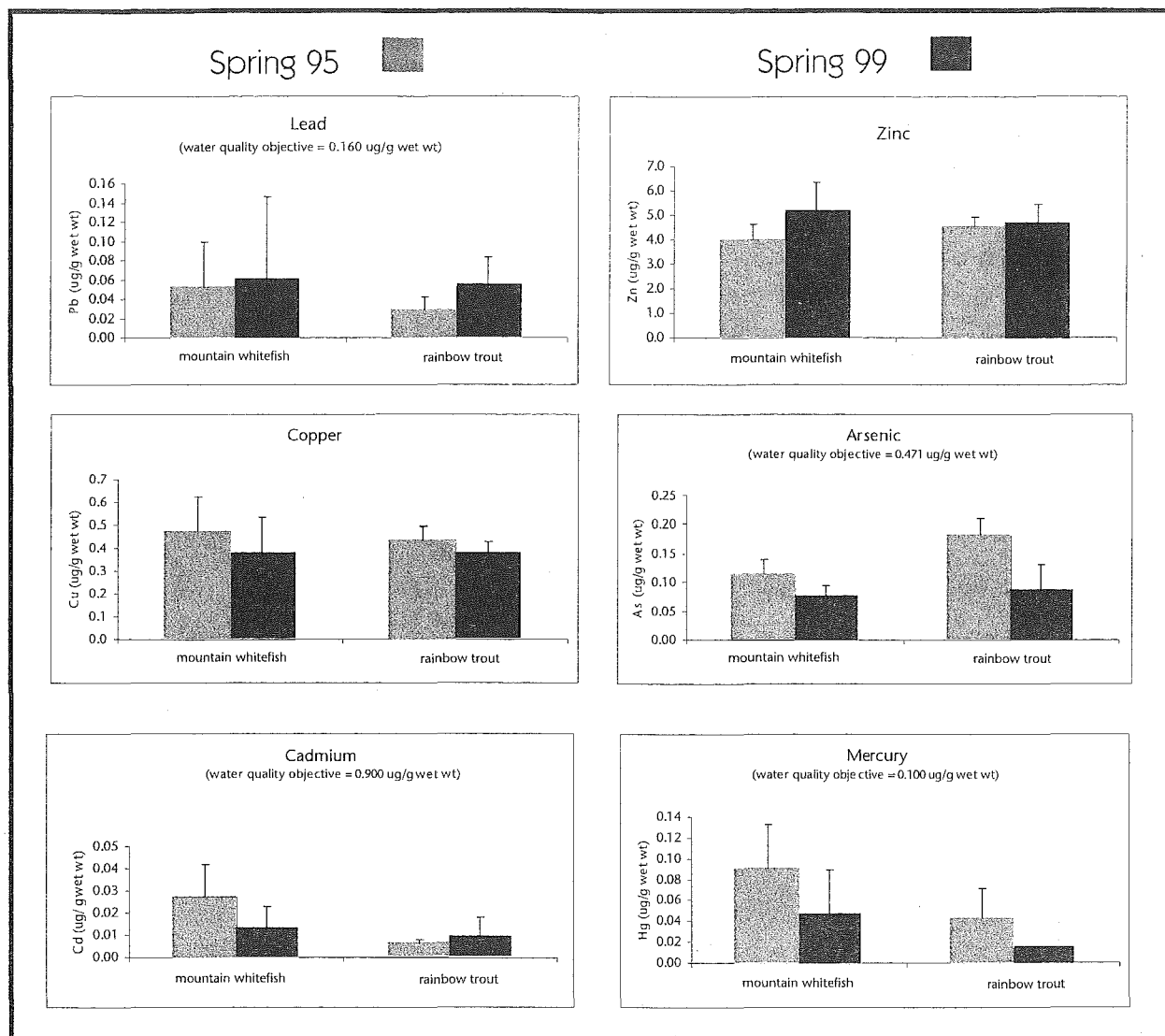
3.8 Fish

Fish provide a relevant indicator of river health because they have the potential to accumulate metals and other contaminants passed through the food web. In turn, contaminants in fish eaten by predators may present a health hazard, of particular concern when the predators are human. Two consumption advisories for fish flesh (muscle) were in effect for several years, limiting consumption to one or two servings of fish per week. The advisory for mountain whitefish and lake whitefish was related to dioxins and furans originating from the Celgar pulpmill. This advisory was lifted in 1997, when decreased levels of these compounds were measured in water, sediment and fish. The advisory for walleye, related to mercury from Cominco's Trail operations and other sources, was lifted in 1995, after reductions were measured in fish and water. The mercury loads from the smelter were reduced by approximately 50% in 1990 to 1991 and further reduced in 1997; 1999 levels were approximately 5% of 1989 levels.

Metal levels were measured in muscle tissue of mountain whitefish and rainbow trout caught near Trail in spring 1995 and spring 1999. Caution is used when interpreting such data because these



Taking samples of fish tissue.

FIGURE 5 – Metal Levels in Columbia River Fish (mean \pm s.d., n=5)

fish can swim considerable distances in the watershed, making it difficult to show clearly that they have been exposed to a particular source of contaminants. There are a variety of metal sources throughout the Columbia watershed in addition to Cominco Trail Operations. Results were variable for some metals, with a wide range of concentrations measured, perhaps related to fish age and size. In addition, sample sizes were relatively small.

Mean levels of arsenic, cadmium, mercury and lead were well below the limits described by the provincial *Ambient Water Quality Objectives for the Lower Columbia River* for fish tissue in both 1995 and 1999 (Figure 5). A statistically significant decrease in arsenic levels was measured in both species between 1995 and 1999.

Mercury and cadmium were below detection in most fish examined in 1999, with the exception of high mercury levels in two young mountain whitefish, at the limit described by the *Ambient Water Quality Objectives*. Similarly, lead was above the *Ambient Water Quality Objectives* in one mountain whitefish (age unknown) caught in 1999. Mean values are used for comparison with the water quality objectives because such isolated high values and variability are to be expected.

4.0 Conclusions

Several indications of improved health in the Columbia River were observed between 1995 and 1999. During this period, Cominco Trail Operations

stopped discharging slag to the river and began operation of a new KIVCET lead smelter, with significant reductions in effluent metal loads to the river. Substantial reductions in metal levels were measured in water, bottom sediment and suspended sediment in 1999. Periphyton growth appeared to respond to the reduced metal loads with increased biomass at some sites and more similar species composition at all sampling sites in 1999. Aquatic insect studies continued to show a decrease in abundance and species richness immediately downstream of outfalls and an assortment of pollution-tolerant and pollution-intolerant species at each site. Mean metal concentrations in fish muscle tissue were within the provincial objectives in 1999, although the occasional fish tested had higher levels of mercury or lead. The consumption advisory for mercury in walleye was lifted in 1995.

The provincial Ministry of Environment, Lands and Parks establishes ambient water quality objectives for BC. The "objectives specify the characteristics of water, sediment, and fish muscle tissues necessary to protect aquatic life, wildlife, livestock watering, irrigation, recreation and drinking water supplies in this portion of the river." *Ambient Water Quality Assessment and Objectives for the Lower Columbia River, Birchbank to the US Border* was published in 2000, subsequent to the study

described here. Average values measured over a one-month period are listed for arsenic, cadmium, chromium, copper, mercury, lead, thallium and zinc in water, sediment and fish tissue. Previously, objectives were based on maximum rather than average values. These site-specific objectives adapted provincial standards to the lower Columbia River, and provided objectives for sediment, which were lacking in earlier documents.

The river and effluent study was designed to assess upgrades at Cominco Trail Operations in terms of water quality objectives prevailing in 1995 and 1999. Greatly reduced metal levels were measured in 1999, with levels in water meeting the 1995 objectives for maximum and average values. These levels were within the 2000 objectives for average values, with the exception of zinc and cadmium, which slightly exceeded the objectives. At the time of the study, there were no water quality objectives for metals in sediment. When the *Water Quality Objectives* established in 2000 were applied, sediment metal concentrations measured in both 1995 and 1999 at Waneta exceeded the objectives. However, levels improved substantially in 1999 and should continue to decline over time. Environmental standards have changed considerably over time and technology continues to evolve to address recognized issues.

Available Literature

Aquametrix Research Ltd. 1994. *Columbia River Integrated Environmental Monitoring Program (CRIEMP)*. Prepared for the CRIEMP Coordinating Committee.

British Columbia Ministry of Environment, Lands and Parks. 2000. *Ambient Water Quality Assessment and Objectives for the Lower Columbia River, Birchbank to the US Border*. Available at <http://www.env.gov.bc.ca/wat/wq/objectives/lowcolum/lowercolumbia.html>

G3 Consulting Ltd. 2001. *Environmental Performance Review of the New KIVCET Lead Smelter and Elimination of Slag Discharge: Assessment of Columbia River Receiving Waters*. Final report prepared for Cominco Ltd. Trail Operations.

MacDonald Environmental Services Ltd. 1997. *Lower Columbia River from Birchbank to the International Border: Water Quality Assessment and Recommended Objectives. Technical Report*. Prepared for Environment Canada and BC Ministry of Environment, Lands and Parks.

For further information, please contact:
Bill Duncan, Senior Biologist
Cominco - Trail Operations
P.O. Box 1000
Trail BC, V1R 4L8
telephone: (250) 364-4336
e-mail: bduncan@trail.cominco.com

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